

PATENT SPECIFICATION

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(54) IMPROVEMENTS IN OR RELATING TO THE OPEN END SPINNING OF FIBRES

(71) We, FELDMÜHLE AKTIEN-GESELLSCHAFT, formerly known as FELDMÜHLE ANALAGEN- UND PRODUKTIONSGESELLSCHAFT MIT BESCHRÄNKTER HAFTUNG, a body corporate organised under and according to the laws of the Federal Republic of Germany, of 4 Düsseldorf-Oberkassel, Fritz-Vomfelde-Platz 4, Federal Republic of Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a method of and an apparatus for spinning staple fibres which are continuously supplied, for example, in the form of a sliver, to a spinning rotor, from which the staple fibres are drawn in the form of a yarn, axially and under tension.

In open end rotor spinning machines the twist imparted can be positively influenced or enhanced by means of special draw-off nozzles situated in the region of the spinning chamber. When the thread is drawn out of the rotor it passes through a draw-off nozzle whereby in conjunction with the speed of the rotor, two speed components result which are of considerable influence. The draw-off speed in the longitudinal direction of the thread is between 60 and 150 metres per minute whilst the velocity of revolution of the thread, that is to say, the speed resulting from the rotational speed of the rotor, is substantially higher, although the thread rotates at a lower speed than the rotor to allow spinning-in of the separate fibres of the yarn. The usual rotor speeds are in the range of from 20,000 to 60,000 revolutions per minute.

Depending on the diameter of the draw-off nozzle with which the thread comes into contact, the speed of the thread relative to the draw-off nozzle may be above 1,500 metres per minute. Thus, the thread rubs the surface of the draw-off nozzle at a very high speed.

Previously proposed draw-off nozzles, as described, for example, in German Offenlegungsschrift No. 1,806,054, have a rounded entrance to the thread withdrawal channel, the surface of which is polished and is also so grooved as better to impart the twist. It often consists of metal which has either been hardened or subjected to a special surface treatment. Nevertheless these draw-off nozzles are subjected to unacceptably high rates of wear which above all very quickly destroys the shaping of the entrance portion. In order to compensate for this disadvantage it is necessary to operate at a higher yarn twist which results not only in increased wear but also in losses of production since the shaping of the draw-off nozzle substantially impairs the appearance of the yarn, and also the number of thread breakages increases as the wear increases. Impairment as a result of wear also occurs in draw-off nozzles without grooves, which as a result of the wear have chatter marks, that is to say, they are no longer smoothly curved, but have a faceted appearance. In the case of different degrees of wear of the draw-off nozzles, which is what normally occurs, because the wear is uncontrollable, the quality of the yarn produced by a machine varies from one spinning unit to another. This can progress to such an extent that a completely unusable yarn is discharged from some spinning units, whereas other spinning units produce a completely satisfactory or only slightly damaged yarn. Considerable expenditure is then necessary in order continuously to check the draw-off nozzles for wear and to equip a machine always with nozzles which have worn to the same extent so as to keep the quality of the yarn from different nozzles at the same level.

The wear of the draw-off nozzles is obviously dependent on the material to be spun. The greatest wear occurs when spinning synthetic fibres, especially those which are strongly pigmented, such as, for example, spin-dyed polyester fibres.

Draw-off nozzles of conventional design,

usually consisting of steel, often have an external thread so that they are easy to change. Changing the nozzles is necessary, however, not only because of the high degree of wear, but also because of the different types of yarn which are produced on the spinning machines. Very important factors, which make special demands both on the geometrical shape and on the surface roughness of the nozzles, are the fibre length, the titre and the nature of the material. Obviously the required fineness of the yarn is a factor affecting the specification of the nozzle. It was hitherto believed that all these requirements could be met only by using draw-off nozzles consisting of hardened steel, although the disadvantages of these, such as the above-described high degree of wear and the additional susceptibility to rust which renders any nozzle immediately unusable even when there is only the slightest formation of rust, were known.

Recently a draw-off nozzle consisting of lithium/aluminium silicate which had been sintered at temperatures above 1150°C was proposed in Offenlegungsschrift No. 2,122,998. As a result of the use of this ceramic material, which may optionally, by the addition of chromium, have imparted to it the property of a cermet, a higher friction should be achieved between the nozzle and the thread, thereby producing a better spinning stability which means that a lower rotor speed can be used to achieve the same required minimum number of twists per inch of thread. Simultaneously the difficulties arising regarding the formation of rust on the metal are avoided and a prolongation of the life of the nozzle is achieved.

However, it was not possible to carry through this proposal in practice, because, first, the intended higher friction of the ceramic consisting of lithium/aluminium silicate resulted in damage to the fibres and, furthermore, because of its structural design, this material neither has the ideal hardness and the high resistance to wear desired, nor has the long life likewise required of it. A further disadvantage is that lithium compounds are relatively scarce and, because of their increasing importance in nuclear fission plants, are obtainable on the market only at high prices and in limited quantities. The most important reason for the fact that it has not been possible to use ceramic nozzles in practice, in spite of the known good properties of, for example, sintered aluminium oxide, is that not only is the oxide ceramic more difficult to machine than the metals hitherto used, but also, on account of its different structure it behaves differently and thus a geometric shape known to be suitable for a metal nozzle

cannot simply be used for a ceramic nozzle.

It is desirable to provide a nozzle which has a surface which does not damage the threads or which results in reduced damage to the threads, which possesses a thread friction behaviour that is substantially constant, or at least varies rapidly, than that of metal nozzles, and is predictable for a long period of time, which is extremely wear resistant and resistant to corrosion and which also has a good breaking strength. It is furthermore desirable to be able to spin as many different types of yarn as possible with one nozzle, that is to say, the individual nozzles should be very versatile in use and it should not be necessary to use a different nozzle for each yarn.

The invention provides a process for the open end spinning of staple fibres, wherein the fibres are continuously supplied to a spinning rotor from which the staple fibres are drawn in the direction of the axis of rotation of the rotor and under tension in the form of a yarn, the yarn being drawn through a draw-off nozzle of sintered ceramic material, wherein the draw-off nozzle has a channel portion and an inlet funnel that tapers towards the channel portion, and wherein the inlet funnel has an actual contact surface (as hereinafter defined) which extends from the channel towards the free end of the inlet funnel for a distance within the range of from 0.2 to 0.3 times the average staple length of the fibres being spun.

The invention also provides apparatus for the open end spinning of staple fibres, wherein in use the fibres are continuously supplied to a spinning rotor from which the staple fibres are drawn in the direction of the axis of rotation of the rotor and under tension in the form of a yarn, the yarn being drawn through a draw-off nozzle of sintered ceramic material, wherein the draw-off nozzle has a channel portion and an inlet funnel that tapers towards the channel portion, and wherein the inlet funnel has an actual contact surface (as hereinafter defined) which extends from the channel towards the free end of the inlet funnel for a distance within the range of from 2 to 24 mm.

The expression "actual contact surface" is used throughout the Specification to mean the area of the surface of the inlet funnel with which the yarn that is being drawn through the draw-off nozzle during the spinning process actually makes contact.

By providing the contact surface in the inlet funnel of the draw-off nozzle in accordance with the invention, one of the especially important factors for the twist of the thread is established. When the draw-off nozzle is made of a sintered ceramic

material, that has a considerable effect on the yarn quality because, in contrast to the usual metal nozzles, the surface structure of the ceramic material remains practically unchanged. This is true both in respect of the so-called "running-in" of the nozzles, which in practice amounts to a continuous polishing in the case of conventional nozzles made of metal, and in respect of the fibre finish.

Man-made fibres attack the draw-off nozzles much more strongly than do, for example, cotton fibres. Man-made fibres are therefore given a conditioning treatment either to reduce or to increase both the fibre-to-fibre friction and fibre-to-nozzle friction. However, the fibre surface furthermore also contains oligomers and delustering agents and these substances influence the frictional behaviour considerably. In the case of metal nozzles this can result in the appearance of deposits on the nozzles, so that the friction varies not only as a result of the continuous polishing but in addition as a result of a "coating" of the surface with oligomers, delustering agents etc.

The contact surface, which in the case of a sintered ceramic material retains a smooth surface and a substantially constant structure for a long time, varies considerably in the case of metals and also in the case of ceramic materials other than sintered ceramics.

The term "sintered ceramic materials" in the context of the afore-going statements is used to mean a material comprising a sintered metal oxide of zirconium, titanium and especially aluminium, as well as mixtures of such oxides. They must be able to withstand the stresses to which they will be subjected in use and have a high purity. Preferably a draw-off nozzle of this type consists of sintered aluminium oxide having a purity of above 99% and a specific gravity of more than 3.90.

By purity it is in the case to be understood that there should, as further constituents in the aluminium oxide, be as little as possible of any alien substance that could lead to the formation of a glass-like intermediate or transition phase. That is not inconsistent with the fact that certain additives such as, for example, magnesium oxide as particle growth inhibitor, or colouring substances, such as chromium oxide, are deliberately added to the starting powders, that is to say, the aluminium oxide. The aluminium oxide of high purity preferably used in accordance with the invention, that is to say, a material that has an aluminium oxide content of more than 99% and thus almost reaches the theoretical specific gravity of 4, has the most favourable properties for the draw-off nozzle. Thus in the case of an aluminium

oxide content of 99.7% the specific gravity is 3.99; the pressure resistance increases to above 300 kp/mm²; the tensile strength is approximately 42 kp/mm²; the bending strength is 53 kp/mm²; the E-modulus is 3.8×10^4 kp/mm² and the Vickers hardness with a test load of 0.1 kg is within the range of from 2,300 to 2,700.

The axial section of the maximum contact surface of the inlet funnel, may be rectilinear but preferably is in the shape of an arc that turns through an angle of 70 to 120 degrees, that is to say, tangents to different points on the arc (the tangents being each regarded as terminating at the point of tangency and all extending from the arc in the same sense) are all contained within a given angle, which angle is within the range of from 70° to 120°. The curve may be of constant radius of curvature. Especially good results are obtained, however, when the arc chosen is a curve having a radius of curvature which, starting from the channel, increases continuously in the direction of the mouth of the inlet funnel.

The expression "axial section of the maximum contact surface of the inlet funnel" is used throughout the Specification to mean the shape of a part of the surface of the inlet funnel as seen in axial cross-section and considering only that part of the cross-section that lies on one side of the axis of the draw-off nozzle, being the part of the surface that could, during the spinning process, be contacted by the thread for any line of approach of the yarn to the mouth of the funnel.

Preferably, the position of the contact surface relative to the rotor can be varied by displacing the draw-off nozzle. This enormous advantage, which can be economically achieved only with draw-off nozzles of sintered oxide ceramic materials, (because a metal nozzle would have to be "run-in" every time it was displaced), allows the use of one nozzle for a plurality of yarn numbers and yarn materials, whereas in the case of a nozzle made of a different material, but of the same geometrical design that would not be possible and nozzles of different geometrical design would be required for different yarn. With the same surface roughness and the same surface profile it is possible, simply by moving the nozzle towards or away from the rotor, to vary the length of the contact surface between the nozzle and the thread by a small amount, and thus adapt the contact surface to the length of the fibre used. By moving the nozzle away from the rotor, the length of the contact surface is reduced: by bringing the nozzle closer towards the rotor, it is increased.

The frictional behaviour between the

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thread and the nozzle is influenced by various factors. These include the type of yarn, the draw-off speed, the nature of the contact surface, the preparation of the yarn, as well as the humidity and temperature of the surroundings and the nature of the surface of the ceramic material. A very important factor, however, is the tension with which the yarn is drawn or, more accurately, the ratio of the thread draw-off tension measured downstream of the nozzle F2 to the calculated thread feed tension F1 between the rotor and the nozzle. Advantageously, that ratio is within the range of from 1.2 to 2.0. The thread feed tension F1, although dependent on machine parameters, the type of fibre and the yarn number, is with the same data always a constant value which can be changed only to an insignificant extent. This value is dependent on the rotor speed, the fibres and the diameter of the rotor, and represents a force which, together with the friction in the nozzle, must be overcome. If the surface shape of the nozzle is kept the same, the friction occurring is therefore varied by the varying thread feed tension F1. The thread draw-off tension F2 is easily measured, and must in any case be greater than F1 since the friction in the nozzle must be overcome.

Since the surface roughness in ceramic materials cannot give any clear indication of the frictional values because the surface may be formed in different ways; specifications of the depth of roughness are only reliable subject to certain qualifications. Photographs taken with a scanning electron microscope clarify this apparent contradiction by showing that the important factor is the surface structure, which is influenced by different sintering conditions and different methods of finishing the surface. Thus, for example, surfaces with decidedly sharp-edged rugosities are obtained by sandblasting ceramics, which surfaces, with a given depth of roughness, cause a relatively high degree of wear of the threads. In contrast, directly ready-made sintered surfaces have, depending upon the sintering conditions, more of an orange peel effect and are also very smooth.

The control of the ratio of the thread tensions thus gives to the man skilled in the art a very simple means, which is relatively easy to influence, for controlling the entire spinning process.

Preferably, the nozzle body has, in the region of the inlet funnel, a depth of roughness, defined as the arithmetic mean of the distance of the surface from its mean level, and determined in accordance with DIN 4768 (August 1974) corresponding to ISO standard No. R 468 (1966), of 0.2 to 0.7 μm and, in the region of the channel, a

depth of roughness of less than 0.2 μm . The difference in roughness between the inlet funnel and the channel is very important for the formation of the thread. The greater depth of roughness in the region of the inlet funnel provides for the high and constant friction that is necessary for the twist of the individual fibres and thus for the formation of the thread, whereas, once the thread is formed, it is desirable to have as low as possible a friction in order to preserve the thread that has been formed. The channel is therefore substantially smoother than the inlet funnel. The depth of roughness is very substantially dependent on the sintering conditions and the purity of the starting material, as well as on the additives which regulate the growth of particles. If there is used as starting material, for example, a high-purity aluminium oxide, then it is advisable to add small traces of magnesium oxide to obtain as fine a grain as possible. Furthermore, as short as possible a sintering time is desirable as this also hinders the growth of particles.

The depth of roughness to be selected for the inlet funnel is dependent on the fineness of the yarn. The finer the yarn the smaller the depth of roughness should be. The greater (coarser) the yarn the greater the depth of roughness. The optimum depth of roughness is, however, also dependent on the fibre material used. In the case of polyester fibres and polyester fibres which are spun in admixture with cotton, grooves in the region of the inlet funnel are necessary which provide for an oscillation of the yarn, whereas pure cotton fibre can be spun without additional grooved or notched surfaces.

Advantageously, in order to render possible easy differentiation of the nozzles the nozzle bodies are coloured, which is very easily possible by small additions of colouring metal oxides, such as, for example, chromium oxide. Depending on the quantity of chromium oxide used, a delicate pink to deep ruby red colour is produced when aluminium oxide is used as the starting material. If, instead of this, spinels are used, then, for example, deep blue colours may be obtained. It is also possible to achieve a blue colouration by adding cobalt oxide. Brown colourations are obtained by iron/manganese oxide additions and greenish colouring by adding nickel oxide, yellowish-green by adding uranium oxide. The quantity of colouring oxides added is, however, always below 2.5% and is generally in the range of 0.3 to 0.8%, and, when it is required that the aluminium oxide shall be especially pure, is substantially below this.

Several forms of draw-off nozzle constructed in accordance with the

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invention will now be described by way of example with reference to the accompanying drawings, in which:

Fig. 1 is an axial cross-section taken through one form of draw-off nozzle;

Fig. 2 is an axial cross-section taken through a second form of draw-off nozzle;

Fig. 3 is an axial cross-section taken through an end portion of a third form of draw-off nozzle;

Fig. 4 is a plan view of a third form of draw-off nozzle showing the line III—III on which the section of Fig. 3 is taken;

Fig. 5 is a section taken on the line V—V of Fig. 3;

Fig. 6 is an axial cross-section taken through a fourth form of draw-off nozzle;

Fig. 7 is a plan view of the fourth form of draw-off nozzle showing the line VI—VI on which the section of Fig. 6 is taken;

Fig. 8 is a section taken on the line VIII—VIII of Fig. 6;

Fig. 9 is an axial cross-section taken through a fifth form of draw-off nozzle;

Fig. 10 is a plan view of the fifth form of draw-off nozzle showing the line IX—IX on which the section of Fig. 9 is taken;

Fig. 11 is a section taken on the line XI—XI of Fig. 9;

Fig. 12 is a plan view of a sixth form of draw-off nozzle;

Fig. 13 is a section taken on the line XIII—XIII of Fig. 12; and

Fig. 14 is a section taken on the line XIV—XIV of Fig. 13.

Referring to Fig. 1 of the accompanying drawings, in which drawings the same reference numerals are used to refer to corresponding parts of different forms of nozzle, the first form of nozzle comprises a body 1 shaped to form a generally trumpet-shaped funnel portion 2 and a cylindrical channel 3. The body 1 is also formed with a collar portion 4 by means of which the nozzle is mounted in a spinning apparatus.

The length of the first form of nozzle is L1 and the diameter of the channel 3 is D. The internal surface of the trumpet-shaped funnel portion 2 is convex and has a radius of curvature of R1. At the end of the channel 3 remote from the portion 2 the edge of the end of the channel is rounded, the radius of curvature being R2.

The path followed by the axis of a yarn passing through the nozzle is indicated by the chain line 10.

In operation, the yarn is drawn downwardly as seen in Fig. 1 from the rotor or spinning chamber of a spinning machine to which the body 1 of the nozzle is secured by means of the collar 4. The centre-line of the yarn follows the path indicated by the chain line 10.

The nozzle is so mounted on the spinning apparatus that the axial separation between

the nozzle and the rotor or spinning chamber can be varied, thereby varying the length of yarn that is in contact with the trumpet-shaped funnel portion 2 of the nozzle at any one time as is described hereinbefore.

As an example of suitable dimensions for the nozzle shown in Fig. 1, the outer diameter of the collar 4 may be 19.6 mm, L1 may be 29.5 mm, D may be 3.0 mm, R1 may be 5.0 mm, R2 may be 1 mm and the axial length of the collar 4 may be 2.5 mm. As can be seen from Fig. 1, the angle through which the contact surface turns is 90°.

Referring to Fig. 2, the second form of nozzle is in general similar to the first form, but the proportions are different. Thus, as an example of suitable dimensions for the nozzle shown in Fig. 2, the outer diameter of the collar 4 may be 19.0 mm, L2 may be 11.3 mm, R1 may be 7.0 mm, the length of the cylindrical channel 3 may be 4.6 mm, D may be 3.0 mm, R2 may be 1.0 mm and the axial length of the collar 4 may be 2.5 mm.

Referring to Figs. 3 to 5, the third form of nozzle differs from the first and second forms principally in that the contact surface is formed with grooves or notches 5.

As an example of suitable dimensions for the third form of nozzle, the overall length (corresponding to L1 for the first form of nozzle) may be 16.5 mm, the outer diameter of the collar may be 29.0 mm, D may be 4.0 mm, R1 may be 12.0 mm, the axial length of the collar 4 may be 4.00 mm, α may be 60°, β may be 90° and α may be 0.17 mm.

The transition from the arms of the V shaped notches 5 to the curved contact surface of the funnel 2 and the vertices of the notches are rounded with a radius of approximately 0.1 mm.

Referring to Figs. 6 to 8, the fourth of nozzle differs from the third form of nozzle principally in that the contact surface is formed with grooves or notches 6, which differ in configuration from the grooves or notches 5 of the third form of nozzle. In the fourth form of nozzle, the notches 6 are rounded where they meet the body of the nozzle to render the nozzle suitable for use with more delicate spinning material.

As an example of suitable dimensions for the fourth form of nozzle, the outer diameter of the collar 4 may be 19.6 mm the overall length of the nozzle may be 29.5 mm, R3 may be 5 mm, R4 may be 6 mm, D may be 3.0 mm, R2 may be 1.0 mm, R5 may be 0.5 mm, R6 may be 0.2 mm (see Fig. 8) and the axial length of the collar may be 2.5 mm.

Referring to Figs. 9 to 11, the fifth form of nozzle differs from the third and fourth forms of nozzle in that the contact surface is formed with grooves or notches 8 of which the configuration differs from that of the grooves or notches 5 and 6. Also, as with the

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other forms of nozzle described with reference to the drawings, the body 1 of the nozzle may be provided with a step 9 instead of the collar 4, if the features of the spinning apparatus so require, and the collar 4 is provided with recesses 7 which serve to prevent relative rotation between the body 1 of the nozzle and the part of the spinning apparatus to which the body of the nozzle is attached.

A significant difference between the fifth form of nozzle and the other forms of nozzle described with reference to the drawings is that, as can be seen from Fig. 9, the contact surface turns through an angle other than 90° .

As an example of suitable dimensions for the fifth form of nozzle, the outer diameter of the collar 4 may be 25 mm, D may be 3 mm, R2 may be 0.8 mm, R7 may be 7.0 mm, the total angle through which the contact surface turns may be 118° , γ may be 60° , δ may be 55° , β may be 0.17 mm and the overall length of the nozzle may be 16 mm.

The transitions between the notches 8 and the funnel 2, and the vertices of the notches, are rounded with a radius of approximately 0.1 mm.

Referring to the Figs. 12 to 14, in the sixth form of nozzle, the contact surface is formed with grooves or notches 6 and 11, the configuration of which can be seen from the drawings.

As an example of suitable dimensions for the sixth form of nozzle, the outer diameter of the collar 4 may be 20 mm, the length of the nozzle may be 39 mm, D may be 3.0 mm, R may be 1 mm, the axial length of the collar 4 may be 5.0 mm, R9 may be 0.2 mm, the height from trough to crest of the grooves or notches 11 may be 0.4 mm, δ may be 6° , ϵ may be 45° and R8 may be 5.0 mm.

In all the forms of drawn-off nozzle shown in the drawings the nozzle body 1 consists of sintered, high-purity aluminium oxide, and is divided into the trumpet funnel 2 and the channel 3. The reference numeral 4 indicates the collar which forms the support in the open-end rotor spinning machine. The V-shaped notches 5 are made in nozzles which are produced according to the injection moulding process, wherein the angle between the arms of the V is approximately 90 degrees. The transition from the V-arms of the notch to the trumpet neck is rounded, as is also the vertex of the notch as such. The angle α i.e. the angle at which the individual notches are inclined in the direction of the narrowing of the funnel, is 60 degrees.

In each of the draw-off nozzles shown in the drawings, the broken line 10 shows the course of the thread in the draw-off nozzle, but it does not show precisely where the thread is actually in contact with the wall

inside the nozzle body 1. Generally, it is the case that there should be practically no contact, and there is practically no contact, between the thread and the nozzle body 1 in the channel 3, the contact actually taking place in the trumpet funnel 2. It is possible, by displacing the nozzle along the draw-off direction, to alter the feed angle of the thread and, by means of this, to vary the area over which the thread is in contact with the trumpet funnel 2. By varying the arc over which the funnel 2 (as seen in axial section) is in contact with the thread the length of the actual contact surface is altered.

The fibres used in the invention may vary in length over a considerable range, for example, from 10 mm in the case of short staple cotton fibres to 250 mm in the case of coarse wool fibres. Synthetic fibres (including polyacrylonitrile, polyamide, polyester, polypropylene and polyethylene fibres) vary in length between 25 and 175 mm. Rayon fibres vary in length from 30 to 150 mm. In general, however, the fibres that are especially important from the point of view of the invention have lengths that do not exceed 80 mm.

The length of the actual contact surface varies, as is explained hereinbefore, when the axial separation between the spinning chamber or rotor and the nozzle is changed, the contact length decreasing as the nozzle is moved away from the rotor. The said axial separation may be substantially zero or even negative, that is to say, the nozzle (especially when the maximum contact surface turns through more than 90°) may actually extend within the rotor.

Since the length of the actual contact surface is within the range of from 0.2 to 0.3 times the fibre length, and the invention is primarily concerned with fibres of lengths between 10 and 80 mm, the contact length will usually be within the range of from 2 to 24 mm.

The nozzle is usually stationary, but it may be mounted for rotation about its axis and may be arranged to be driven, usually in a sense opposite to the sense of rotation of the rotor.

The following Examples illustrate the invention.

EXAMPLE 1

An alumina having a purity of above 99.7% by weight of Al_2O_3 and obtained from crude bauxite materials according to the Bayer process was ground, together with 0.25% magnesium oxide as a sintering auxiliary, to a particles size of an average of $1 \mu\text{m}$. The grinding as well as the dispersing was effected in aqueous dispersion, and following this the water was removed from the powder by spray-drying in a current of

hot air. Particles capable of being sprinkled were thus produced, and they had diameters in the range of from 60 to 150 μm . The powder, which had a weight of 1 kilogramme per litre, was in order to facilitate the later moulding operation, moistened with water to a maximum of 2.5%. The compression of this powder into green compacts was carried out in a finishing press, in which the mould consisted of hard metal. The mandrel used to form the channel of the thread draw-off nozzle, had a higher polish than the bulge adjoining the mandrel, which bulge served to produce the trumpet-shaped funnel of the draw-off nozzle. The pressure applied was approximately 1,000 kp/cm^2 . The green compact obtained had a higher degree of smoothness in the channel than in the trumpet funnel and had a chalk-like consistency. After removing the flash, the green compact was introduced into a periodically operating high-temperature furnace and heated to a temperature of approximately 1,750°C. The sintering time, inclusive of heating and cooling, was 24 hours. Following the sintering, the draw-off nozzle was freed from adhering particles of corundum which had been scattered onto the combustion auxiliary during sintering and prevented the part from being baked.

EXAMPLE 2

The preparation of the aluminium oxide was carried out in the manner specified in Example 1, except that following the moistening stage there was a plasticisation stage, that is to say, the powder was plasticised with an organic material in batches in a kneader, to form thermoplasts having a high content of Al_2O_3 . The shaping was carried out by an injection process using a worm extruder, as is customary today for injection-moulding plastics articles. It was necessary to remove the organic constituents again from the resulting extruded member before sintering in order to prevent cracks owing to the gas pressure of the decomposing organic fraction. This drying process was carried out in a drying oven at temperatures of between 300 and 600°C. Following the drying, the flash on the draw-off nozzle was removed, the seam between sections of the mould lying outside the thread-guiding area of the nozzle. The sintering was carried out as described in Example 1.

EXAMPLE 3

In contrast to Example 1, the purity of the alumina was reduced to a content of 99.2% aluminium oxide, 0.2% magnesium oxide was added as growth inhibitor, and 0.5% chromium oxide was added for colouring.

The other process steps were the same as those indicated in Example 1.

The draw-off nozzles produced according to Example 1 and 3 had a channel which was smoother than the trumpet funnel. The depth of roughness (as hereinbefore defined) in the channel was in both Examples 0.2 μm , and in the region of the funnel was 0.4 μm . The injection-moulded nozzle according to Example 2 had the same smoothness in the channel and funnel—both surfaces were polished—and in comparison with the draw-off nozzles according to Examples 1 and 3 had a greater radius in the axial-section of the maximum contact surface of the inlet funnel. In the case of the injection-moulded nozzle, that radius was 12 mm and the arc turned through an angle of 115 degrees, whereas the compressed nozzles had a radius of 5 mm and turned through an arc of 90 degrees.

WHAT WE CLAIM IS:—

1. A process for the open end spinning of staple fibres, wherein the fibres are continuously supplied to a spinning rotor from which the staple fibres are drawn in the direction of the axis of rotation of the rotor and under tension in the form of a yarn, the yarn being drawn through a draw-off nozzle of sintered ceramic material, wherein the draw-off nozzle has a channel portion and an inlet funnel that tapers towards the channel portion, and wherein the inlet funnel has an actual contact surface (as hereinbefore defined) which extends from the channel towards the free end of the inlet funnel for a distance within the range of from 0.2 to 0.3 times the average staple length of the fibres being spun.

2. A process as claimed in claim 1, wherein the axial section of the maximum contact surface of the inlet funnel (as hereinbefore defined) is in the shape of an arc that turns through an angle in the range of from 70 to 120 degrees.

3. A process as claimed in claim 1 or claim 2, which is carried out using apparatus in which the position of the draw-off nozzle in relation to the position of the spinning rotor can be adjusted in the direction of the common axis of the rotor and the nozzle to alter the line of approach of the yarn to the mouth of the funnel and hence to alter the length of the actual contact surface (as hereinbefore defined).

4. A process as claimed in any one of claims 1 to 3, wherein the ratio of the measured tension of the yarn being drawn off downstream of the draw-off nozzle to the calculated tension of the yarn being fed from the rotor to the draw-off nozzle is in the range of from 1.2 to 2.0.

5. A process as claimed in any one of claims 1 to 4, wherein at least the contact surface of the draw-off nozzle consists of sintered aluminium oxide having a purity of at least 99% and a specific gravity of at least 3.90.
6. A process as claimed in any one of claims 1 to 5, wherein the contact surface of the inlet funnel of the draw-off nozzle has a depth of roughness, measured as hereinbefore defined, within the range of from 0.2 to 0.7 μm .
7. A process as claimed in any one of claims 1 to 6, wherein the channel of the draw-off nozzle has a depth of roughness, measured as hereinbefore defined, not exceeding 0.2 μm .
8. Apparatus for the open end spinning of staple fibres, wherein in use the fibres are continuously supplied to a spinning rotor from which the staple fibres are drawn in the direction of the axis of rotation of the rotor and under tension in the form of a yarn, the yarn being drawn through a draw-off nozzle of sintered ceramic material, wherein the draw-off nozzle has a channel portion and an inlet funnel that tapers towards the channel portion, and wherein the inlet funnel has an actual contact surface (as hereinbefore defined) which extends from the channel towards the free end of the inlet funnel for a distance within the range of from 2 to 24 mm.
9. Apparatus as claimed in claim 8, wherein the axial section of the maximum contact surface of the inlet funnel (as hereinbefore defined) is in the shape of an arc that turns through an angle in the range of from 70 to 120 degrees.
10. Apparatus as claimed in claim 8 or claim 9, in which the position of the draw-off nozzle in relation to the position of the spinning rotor can be adjusted in the direction of the common axis of the rotor and the nozzle to alter the line of approach of the yarn to the mouth of the funnel and hence to alter the length of the actual contact surface (as hereinbefore defined).
11. Apparatus as claimed in any of claims 8 to 10, wherein in use the ratio of the measured draw-off tension of the yarn downstream of the draw-off nozzle to the calculated thread feed tension between the rotor and the draw-off nozzle is within the range of from 1.20 to 2.0.
12. Apparatus as claimed in any one of claims 8 to 11, wherein at least the contact surface of the draw-off nozzle consists of sintered aluminium oxide having a purity of at least 99% and a specific gravity of at least 3.90.
13. Apparatus as claimed in any one of claims 8 to 12, wherein the contact surface of the inlet funnel of the draw-off nozzle has a depth of roughness, measured as hereinbefore defined, within the range of from 0.2 to 0.7 μm .
14. Apparatus as claimed in any one of claims 8 to 13, wherein the channel of the draw-off nozzle has a depth of roughness, measured as hereinbefore defined, not exceeding 0.2 μm .
15. Apparatus as claimed in any one of claims 8 to 14, wherein the draw-off nozzle is substantially as hereinbefore described with reference to, and as shown in, Fig. 1, or Fig. 2, or Figs. 3 to 5, or Figs. 6 to 8, or Figs. 9 to 11, or Figs. 12 to 14, of the accompanying drawings.
16. Apparatus as claimed in any one of claims 8 to 15, wherein the draw-off nozzle is coloured.
17. Apparatus as claimed in claim 16, wherein the colouring of the nozzle has been effected by the addition of a small quantity of an oxide or oxides other than aluminium oxide.

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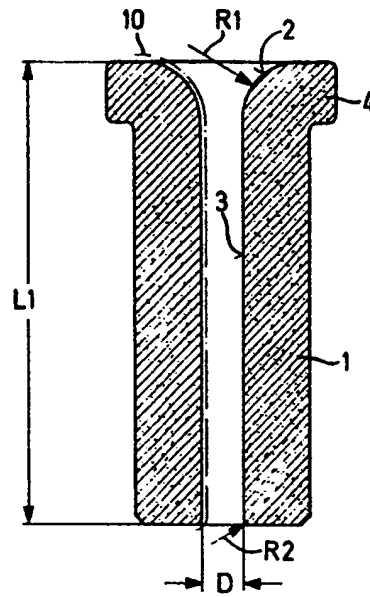


Fig. 1

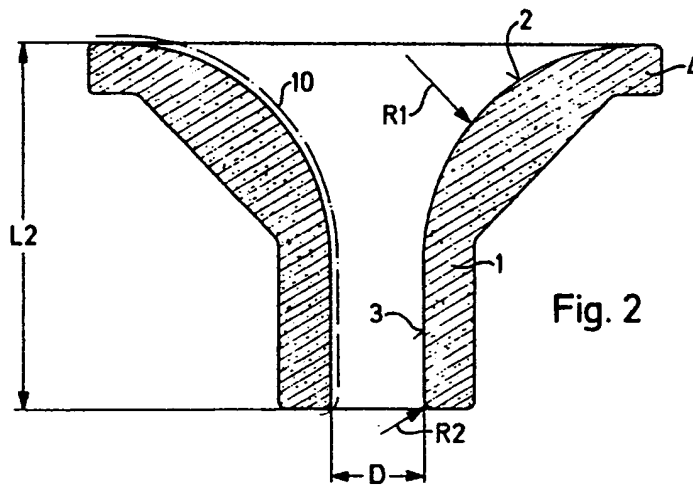


Fig. 2

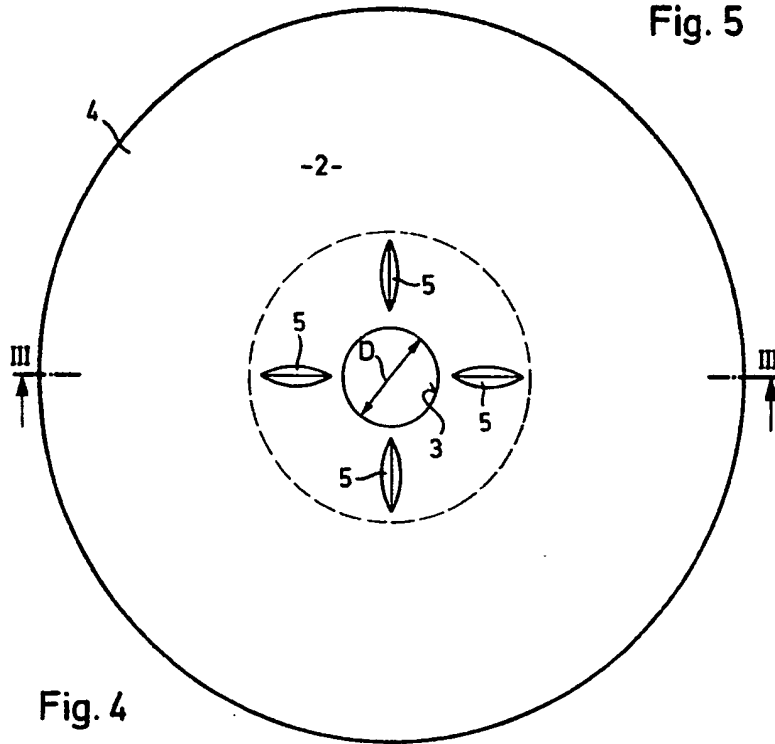
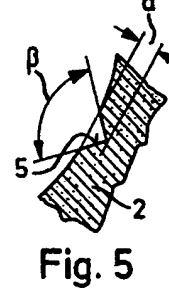
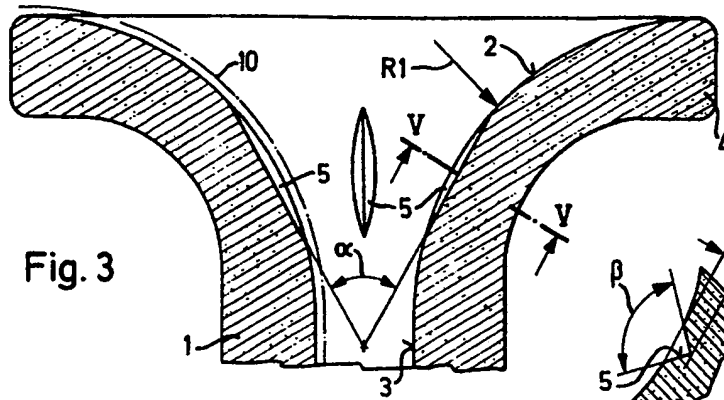


Fig. 6

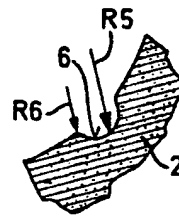
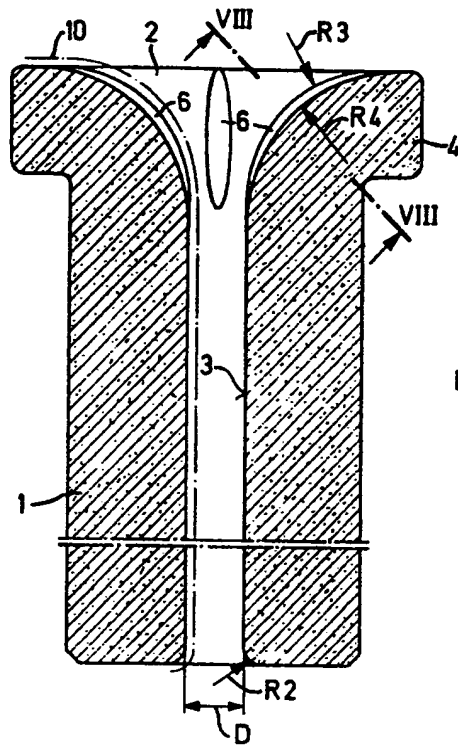


Fig. 8

Fig. 7

